BIOMECHANICAL ANALYSIS OF WEIGHTLIFTING

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ABSTRACT

Weightlifting is a sport that requires good strength and appropriate technique to make a weightlifter success in its lift. Weightlifting contains two main technique which are snatch technique and clean-jerk technique. Both techniques have six phase and the phases are, first pull; transition from first to second pull; second pull; turnover under the barbell; catching phase; rising from squat position. This project is about the biomechanical analysis on the weightlifting and the result from the experiment will be compared with other researcher. This experiment is only for preliminary study for this thesis. The objectives for this experiment are to investigate the force exerted, observe the muscle activity and study the angle of joint on the subjects while lifting the barbell for both techniques. In force distribution and muscle activity analysis, only one subject is selected to do the comparison as all subjects shows almost same pattern of graph in the experiment. From the result of angle of joint, all the subjects is compare with each other's and only one subject is selected for comparison with the professional athlete. From the result shown by the subject and comparison with the professional athlete, the technique shown by the subject is not much different. Analysis on weightlifting also important as it can reduce the injuries and increase the performance for the lifter.

ABSTRAK

Angkat berat adalah sukan yang memerlukan kekuatan dan teknik yang betul untuk membolehkan ahli angkat berat berjaya dalam dalam angkatannya. Angkat berat mempunyai dua teknik utama iaitu teknik “snatch” dan teknik “clean-jerk”. Kedua-dua teknik mempunyai enam fasa utama iaitu, angkatan pertama; peralihan dari angkatan pertama ke angkatan kedua; angkatan kedua; pembalikan besi pengangkat; fasa tangkapan; bangun dari keadaan mencangkung. Projek ini adalah berkenaan dengan analisis biomekanikal pada angkat berat dan hasil daripada eksperimen akan dibandingkan dengan kajian yang lain. Eksperimen ini adalah untuk kajian awal dalam thesis ini. Objektif untuk eksperimen ini adalah untuk, mengkaji agihan daya, aktiviti otot dan sudut antara anggota badan pada subjek semasa mengangkat barbell untuk kedua teknik. Untuk analisis agihan daya dan aktiviti otot, hanya satu subjek juga dipilih untuk dibuat perbandingan dengan atlet professional kerana semua subjek menghasilkan bentuk graf yang agak sama ketika eksperimen. Keputusan sudut antara anggota badan dari eksperimen akan dibandingkan antara subjek dan hanya satu subjek dipilih untuk dibuat perbandingan dengan atlet professional. Keputusan dari subjek dan perbandingan dengan atlet professional menunjukkan teknik yang dilakukan oleh subjek tidak banyak bezanya. Analisis untuk angkat berat adalah penting kerana ia boleh mengurangkan kecederaan dan menambahkan prestasi ahli angkat berat.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

This study is mainly about weightlifting technique in a sport and the effect of weightlifting technique from the distribution force, angle of joint and muscles activity produce by the lifter. Biomechanics in this project is the study and analysis about the weightlifter and the activities of weightlifting in general. Weightlifting consists of two main technique which are snatch technique and clean-jerk technique. Snatch technique is lifting the barbell from the platform and locked arms overhead in a smooth continuous movement. A lifter then will pull the barbell as high as he or she can. In this technique, power and strength is very important to the athlete but the technical skills, excellent balanced, speed and shoulder flexibility cannot be put aside as all of it also can affects to a good technique during the lifting. Clean-jerk technique is another technique in weightlifting where it is the part when the lifter explosively pulling the weight from the floor to their racked position and the barbell is across the shoulder. After that, the lifter will do some flips and the barbell will be on the overhead which this part is called jerk technique.

Effect of weightlifting in this study contains three main parts which are distribution force produce by the lifter, angle of joint on lifter's body during the weightlifting and the muscle activity uses in weightlifting. The distribution force will be determined from the experiment measured by using a plantar force in a laboratory. During the experiment run, effect of muscle activity is determine by using electromyography (EMG) to know the most active muscle involve in weightlifting.

Angle of joint is taken from the lifter's body with a digital camera at the certain point. Then, the final report can be done according to the result.

1.2 Problem Statement

In this experiment, the distribution force produce by weightlifter during lifting the barbell is determined at each phase. Each phase will produce different distribution force due to the different style perform by the lifter. Different technique also will result in different distribution force for each lifter and this is important as the lifter has their owned style. From this experiment, each distribution force produce will be compare with another journal.

During the lifting process, the muscles activity also needs to find through the different weightlifting technique because muscles play an important role in weightlifting. Muscles that show the most activity have a higher potential to fatigue early and it can affect the lifter's performance. There are many muscles that can be investigated but only two muscles that will be used in this study.

Last problem statement in this study is to determine the angle of joint from the lifter's body. Angle of joint can prove the correctness of weightlifting technique. It also will be compare between the subject and professional athlete to see whether subject in the experiment has the correct technique.

1.3 Objective

i) To investigate the force exerted during the weightlifting technique.
ii) To observe the muscle activity in weightlifting.
iii) To study the angle of joint during weightlifting.

1.4 Project Scope

i) Determine the maximum force occur while a lifter lift a weight base on the technique phase.
ii) Find the most active muscle between two muscles during the weightlifting.
iii) Study the angle of joint at hip, knee and ankle in a weightlifting technique.
iv) Determine the barbell kinematics during the experiment.

1.5 Organization of the report

This study involves of five chapters in the report. For PSM 1, this report only include until chapter 3 which are introduction for chapter 1, literature review for chapter 2 and methodology for chapter 3. For chapter 1, the introduction involve of project background of the study which is about the weightlifting and its technique. It also include with the objective, problem statement and the project scope of the study.

Chapter 2 of the report consists of the literature review relating to the title of the study which is the biomechanics analysis of weightlifting. Source of literature review is taken from the journal, article, and book or from the internet. In this chapter, it tells about the weightlifting and the overall information of weightlifting technique which are snatch technique and clean-jerk technique. Besides that, the biomechanics and injury in weightlifting also is in this chapter where it shows that weightlifting consist of many information about it. Furthermore, the muscle involve during the weightlifting also explain in this chapter and also the force produce during the weightlifting technique.

Meanwhile, in chapter 3 of this report, it explains about the methodology for the experiment, the subject, equipment use and the procedure. Briefly explanation about the both snatch technique and clean-jerk technique also include in this chapter. A flowchart for the experiment also can be seen in this chapter where it can give more understanding on how the experiment going.

Chapter 4 for this report is about the result and analysis from the experiment. Result in chapter 4 is divided into four main parts which are distribution of force, angle of joint, barbell kinematics and muscle activity. Meanwhile, chapter 5 in this report explains about the overall conclusion for the experiment and recommendations to improve the experiment in the future.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This literature review is about the weightlifting and it has two technique which is snatch technique and clean-jerk technique. Besides, it also include the muscle activity involve in weightlifting and other sport for additional information and also the injuries produce in weightlifting. This chapter also discuss about the force distribution that produce during the experiment.

2.2 Weightlifting

Weightlifting is a sport that requires strength and technique to make a lifter success and it is also can be as an exercise to the athlete. Weightlifting sport has two types of technique which are snatch and clean-jerk. In the Olympic competition, each weightlifter can did three attempts for each technique, and combination of two highest successful lifts determines the overall result within a bodyweight category (BBC Sports Olympic, 2012). Bodyweight categories are different for different genders. A lifter who fails to complete at least one successful snatch and one successful clean and jerk also fails to total, and therefore receives an incomplete entry for the competition (BBC Sports Olympic, 2012). Olympic weightlifting tests include in the aspects of human limits strength and therefore implemented faster with more movement and a greater range of motion during their implementation compare

to the other lifts. If the technique is properly implemented, the snatch and the clean and jerk are both dynamic while appearing smoothly, especially when viewed from a slower speed recorder.

Each technique has different phase and different angle in lifting the barbell. In competition, snatch technique will be the first for the competitors to do follow by the clean-jerk technique. Load of the barbell lift by the weightlifter is not the same as each person have different strength and different technique in lifting.

2.2.1 Snatch technique

For the overall view of snatch technique, the lifter will start by setting the position to lift the barbell from the platform. The barbell then will be lift to the mid chest of the lifter and at the certain point, it will be flipped overhead. Some lifter had been done a power snatch which means during the lifting, the lifter does not need to bend their knees because the load of the barbell is currently light (BBC Sports Olympic, 2012). For a clearly understanding, **Figure 2.1** is showing the progress of snatch technique.

Figure 2.1: Snatch technique in a competition

Source: Mike stone, 2012

2.2.2 Clean-jerk technique

Clean and jerk is the combination of two technique which is clean technique and jerk technique. These two techniques are continuous between each other as shown in the **Figure 2.2** and **Figure 2.3**.

i) Clean technique

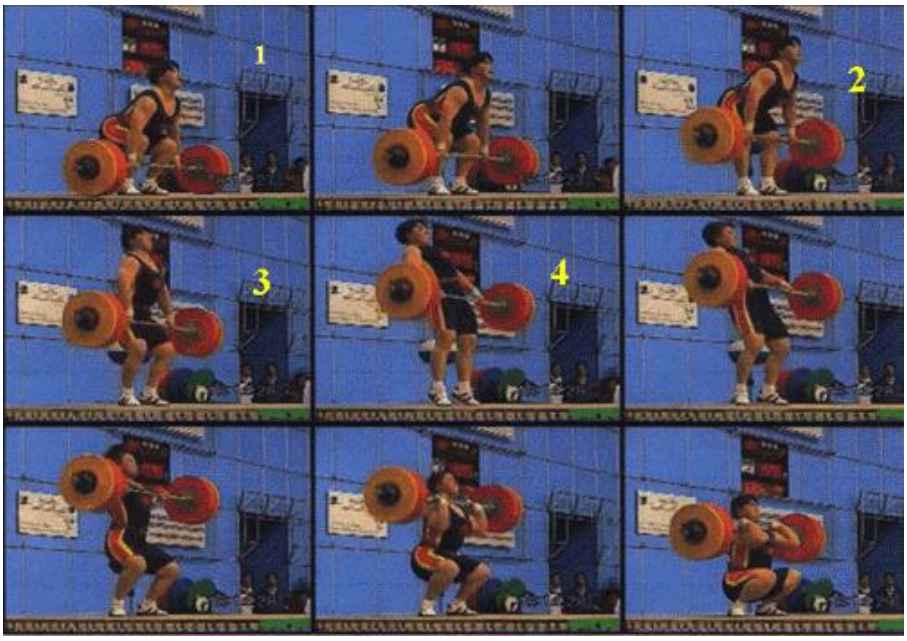

Figure 2.2: Clean technique in a competition

Source: Mike stone, 2012

During this technique, the athlete will begin the lifting in a squat position. Then, the athlete will do hook grip which mean the position of the hand and the hips is only a thumb distance and this hook grip require an athlete grasping the bar so the fingers will go over the thumb. This hand position will make the lifter not easily lose their grip while lifting the barbell. After that, the lifter will pull the barbell upward as high as his shoulder through the quick triple extension of hips, knees and ankles. The lifter then will be pulled under the bar and into a deep front squat position. Finally, the lifter then will stand to continue the second phase which is jerk technique (Mike stone, 2012).

ii) Jerk technique

Figure 2.3: Jerk technique in a competition.

Source: Mike stone, 2012

From the standing position, the lifter then will bend their knees a little bit about 145 degree and push the barbell upwards with their arms while jumping a little until the barbell is above their head. In **Figure 2.3** above, the lifter perform a split jerk where one of the legs is move forward while another leg is move backward. The lifter will stop for a moment at this position to make sure their position with the barbell is stable and finally jump into a standing position (Mike stone, 2012).

2.3 Muscle activity

Term of the muscle is derived from the Latin word '*musculus*' which mean "little mouse". It is call like that because some of the shape of our muscle is small like a mouse and probably the contracting muscles just like a mice moving under the skin (Andrew Charniga, Jr, 2001). Muscle in our body is important if we are active in sport because if our muscle is strong, our ability in sport will be more power and success. Function of our muscle in our body is to produce force and cause motion to

move our body. These muscles are mainly responsible for preservation and changes in posture, locomotion of the organism itself, as well as movement of internal organs.

Normally in weightlifting, there are eight muscles that had been investigated in the experiment. These muscles are three muscles from the back muscle which are deltoideus muscle, latissimus dorsi muscle and trapezius muscle as shown in the **Figure 2.4** below (Xueling Bai, 2008).

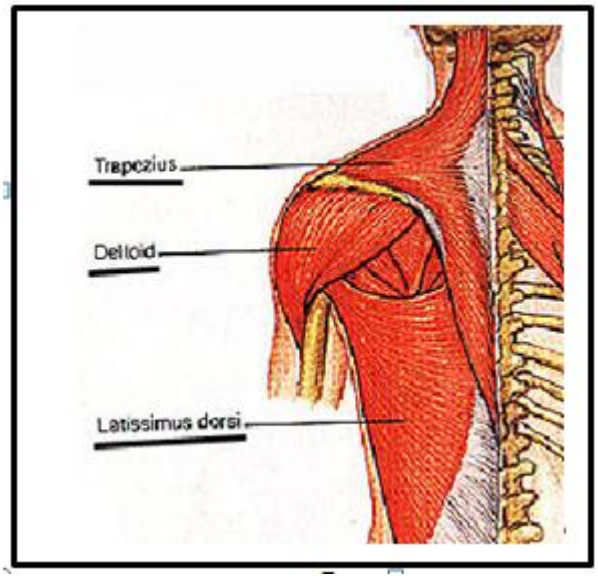

Figure 2.4: Back muscles

Source: Warren, 2012

Another muscle include is at the hand muscles which are triceps brachii muscle and biceps brachii muscle in **Figure 2.5** below:

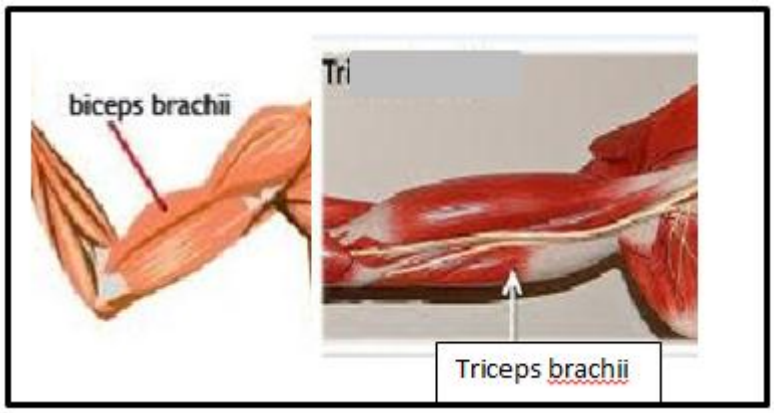

Figure 2.5: Hand muscles

Source: Webstock.com

Leg muscles also important in weightlifting because the starting pull of weightlifting require a power leg muscle to stand up while lifting the barbell. Legs muscles involve are rectus femoris muscle and tibialis interior muscle as shown in **Figure 2.6** below.

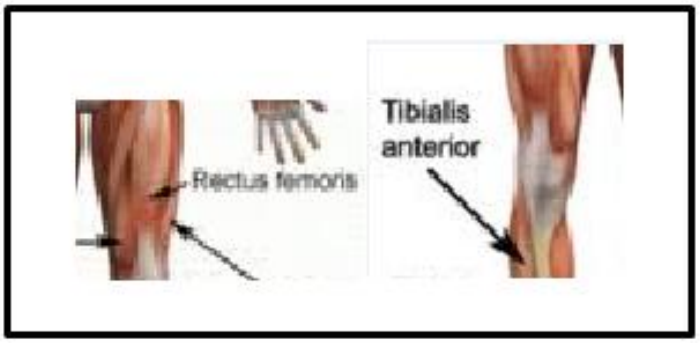

Figure 2.6: Leg muscles

Source: Physio Advisor.com

Another sports also have use many leg muscle as an example water rowing. In this sport, rectus femoris will be use when the rower pushes the canoe (A. Guével, 2011). This leg muscle and hand muscle both play important role during rowing because only both anatomical mainly use while rowing.

Muscle activities had been investigated by using the electromyography (EMG) in the experiment and each muscle gives different result at different phase of weightlifting in the two technique of weightlifting which are snatch and clean-jerk. The EMG is used to calculate the magnitude or the velocity for exerting of a muscle, where exists qualitative but not quantitative relation(Xueling Bai, 2008). **Figure 2.7** shows the example of muscle activities during the snatch technique after the experiment.

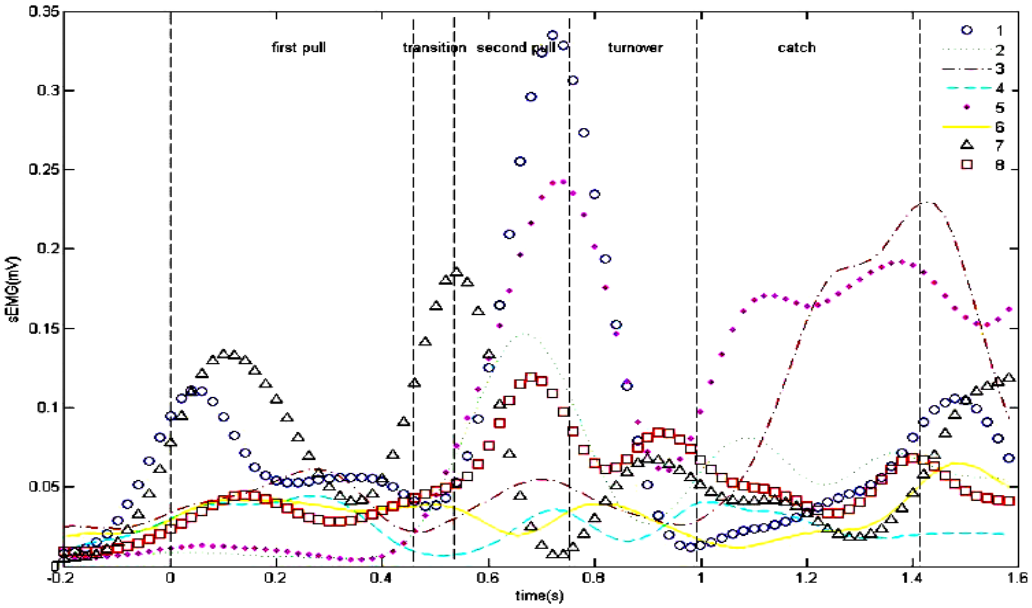

Figure 2.7: Example of 8 muscle activities graph during the snatch technique. 1: M. deltoideus; 2: M. biceps brachii; 3: M. triceps brachii; 4: M. latissimus dorsi; 5: M. trapezius; 6: M. erector spinaeta; 7: M. rectus femoris; and 8: M. tibialis anterior. Source: Xueling Bai, 2008

Another sport also will use EMG to investigate the muscle activity such as the shoulder muscle during playing baseball. Overhead baseball pitch has six phases which are: 1) wind up 2) stride 3) arm cocking 4) arm acceleration 5) arm deceleration 6) follow through (Rafael F. Escamilla, 2009). In this experiment, activities of shoulder muscle increase and decrease at certain phase as shown by the EMG. EMG detects all the movement of muscle during the process and the phases which use more energy on the shoulder muscle will be detected.

2.4 Force distribution

A force is the effect that produces by an object to experience a certain change, either relating to its movement, direction, or geometrical construction. Force also can be described from natural concepts such as a push or pull. A force has both magnitude and direction, making it a vector quantity. Usually, weightlifting will produce force below the lifter because the weight of the barbell and the lifter is

combining to produce a different force at the different phase of lifting technique. Experiment that related to force in weightlifting will use the plantar force as the instrument and it can provide accurate amount of force for each phase in weightlifting technique. Example of force produce is shown in the graph of force versus time below.

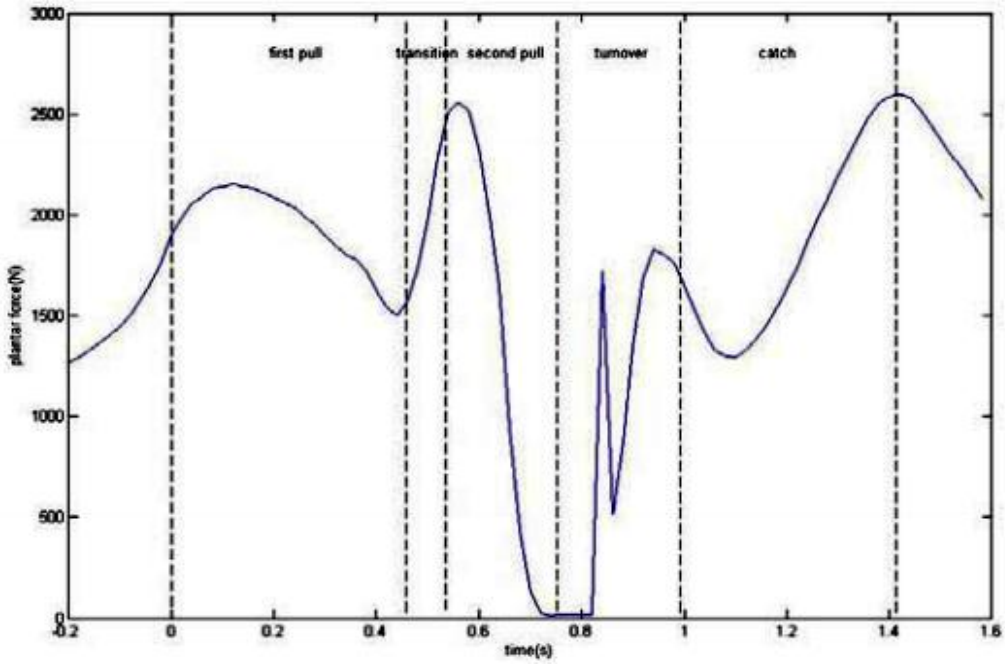

Figure 2.8: Example of force graph result during snatch technique.
Source (Xueling Bai, 2008)

2.5 Injuries in weightlifting

Injuries in sport commonly will occur whether it is bad or not because many factors can produce injuries such wrong technique use, hurt by another player and others. In a research, the overall rate of injury for weight training and weightlifting was 0.0012 per 100 participants (Brian P. Hamill, 1994). This mean a lifter do not have higher rate of having injuries because learning weightlifting require high profile coach. New lifters also learn with light weight until they become familiar with the technique. In this case, injuries happen to weightlifters will be reducing.

From a research, Kotani said that 31% of weightlifters having spondylolysis injuries which mean a disabling spinal degenerative syndrome. From his 26 Olympic weightlifters sample, present of lifters that having spondylolysis is about 7% (Brian P. Hamill, 1994). Other than that, high risk injuries in weightlifting and other sports occur at three anatomical areas which are the shoulder, the knee and low back. Furthermore, weightlifting injuries not only occur at soft tissue muscle but also meniscal injuries and spondylolysis (Gregg Calhoon, 1999).

Clean and jerk technique is the easiest phase where a lifter can get injuries and the result from the research showed that the area of a lifter can get common injury is at the low back where spondylolysis occur (Gregg Calhoon, 1999). Part of the body that also can produce injury to the lifter is at the knee and it is the second critical part compare to the low back. Injuries at knee are mainly the chronic inflammatory problems such as patel-lofemoral osteoarthritis and not the traumatic stability problems from the other sports because in weightlifting, a lifter knee moves in a controlled range of motion (Gregg Calhoon, 1999).

Shoulder of a lifter also has injury that related to the instability which is having extremly lordotic position when pressing motion during clean lift and press lift. Heavy weightlifters are at the highest risk for shoulder injuries such as extreme flexion and abduction (Gregg Calhoon, 1999).

With biomechanical research also injuries can be prevented because with the appropriate technique, less force will be produce at the spine and therefore less the cause of injuries can be avoid (Fortin and Falco, 1997). In the Olympic style of weightlifting, after the second pull when the lifter lift the barbell overhead do not require balancing of large moments but rather tremendous neuromuscular coordination in controlling moments near to the zero(Fortin and Falco, 1997). There are some syndrome and injuries that happen to the lifters such as tired neck syndrome, thoracolumbar syndrome, extremity injuries, sacroiliac joint dysfunction, cardiovascular consequence, spondylolysis, and the most common problem is low back pain (Fortin and Falco, 1997). If this research is followed, all the injuries can be preventing early and all lifters do the correct technique before it getting worst (Fortin and Falco, 1997).

Figure 2.9: Example of spondylolysis injuries.

Source (Pediatric Orthopaedic Department Massachusetts General Hospital)

CHAPTER 3

METHODOLOGY

3.1 Introduction

This methodology is about the setup of the experiment and the process on how this experiment going and the technique of weightlifting. This chapter also include with on how the subject is selected, the equipment that will be use and its function and the flowchart of the experiment. In this chapter also, briefly explanation about the both technique which are snatch technique and clean-jerk technique is being included.

The weightlifting experiment is done only on the plantar force to find the force exerted with the digital camera and electromyography (EMG) also been used. Digital camera is use to capture the picture of lifters in their lifting progress. Then, the result from the experiment will be analyzed for further study.